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STAINLESS STEELS AND THEIR USES ★

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UCC
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PREFACE

ALLOY steels, because of their superior physical properties, have made possible tremendous advances in engineering. Their greater strength and endurance have enabled engineers to reduce the weight of machine parts and equipment and at the same time to increase the factor of safety. This has resulted in greater speeds and improved efficiencies of operation. In the chemical and allied industries their resistance to heat and the corrosive action of many chemicals has resulted in greatly reducing the enormous losses caused by oxidation and corrosion.

The stainless steels, because of their widespread use and popularity, are undoubtedly the best known of the alloy steels. Their beauty, durability and resistance to heat and corrosion make them suitable for use in almost every industrial field, and new uses are being developed so rapidly that it is difficult to keep abreast of them. This booklet has been prepared in the belief that a brief summary of the major applications of the stainless steels will be of great interest to a large number of people. We shall be glad to furnish additional information to anyone desiring more complete details.

ELECTRO METALLURGICAL COMPANY

Stainless Steels And Their Uses

Chromium-Alloy Steels Are Employed in Practically Every Industrial Field

CHROMIUM exerts such a powerful influence on the physical and chemical properties of steel that most of the special steels upon which industry relies for exceptional service contain this element. Although a large number of chromium steels of various types have been developed, these may be conveniently divided into three fairly definite classifications: those containing relatively low percentages of chromium, up to approximately 5 per cent; those with a medium chromium content, up to about 20 per cent; and those containing still higher percentages of chromium.

In general the steels in the group with a relatively low chromium content are suitable for engineering applications where the excellent combination of strength, toughness and hardness, which they possess, makes them particularly desirable. These steels may, and frequently do, contain other alloying elements such as nickel, molybdenum, vanadium and manganese which greatly enhance the physical properties of the plain carbon-chromium steels. Some of the steels in this group, particularly those containing about 5 per cent chromium and a relatively low carbon content, show an improved resistance to atmospheric corrosion, and their resistance to oxidation at elevated temperatures is also much better than that of the ordinary carbon steels.

The splendor of the Empire State Building is enhanced by trim of 18-8 chrome-nickel steel

The second group, containing up to about 20 per cent of chromium, with or without additional alloying elements, consists largely of the steels commonly known as "stainless" or "rustless," distinguished by their great resistance to atmospheric

and certain forms of chemical corrosion. They also show excellent resistance to oxidation at elevated temperatures and are extensively used for high temperature work.

The steels of the third group—those containing over 20 per cent of chromium—are distinguished by their great resistance to oxidation at high temperatures and by their extreme resistance to atmospheric corrosion and a wide variety of chemical attack.

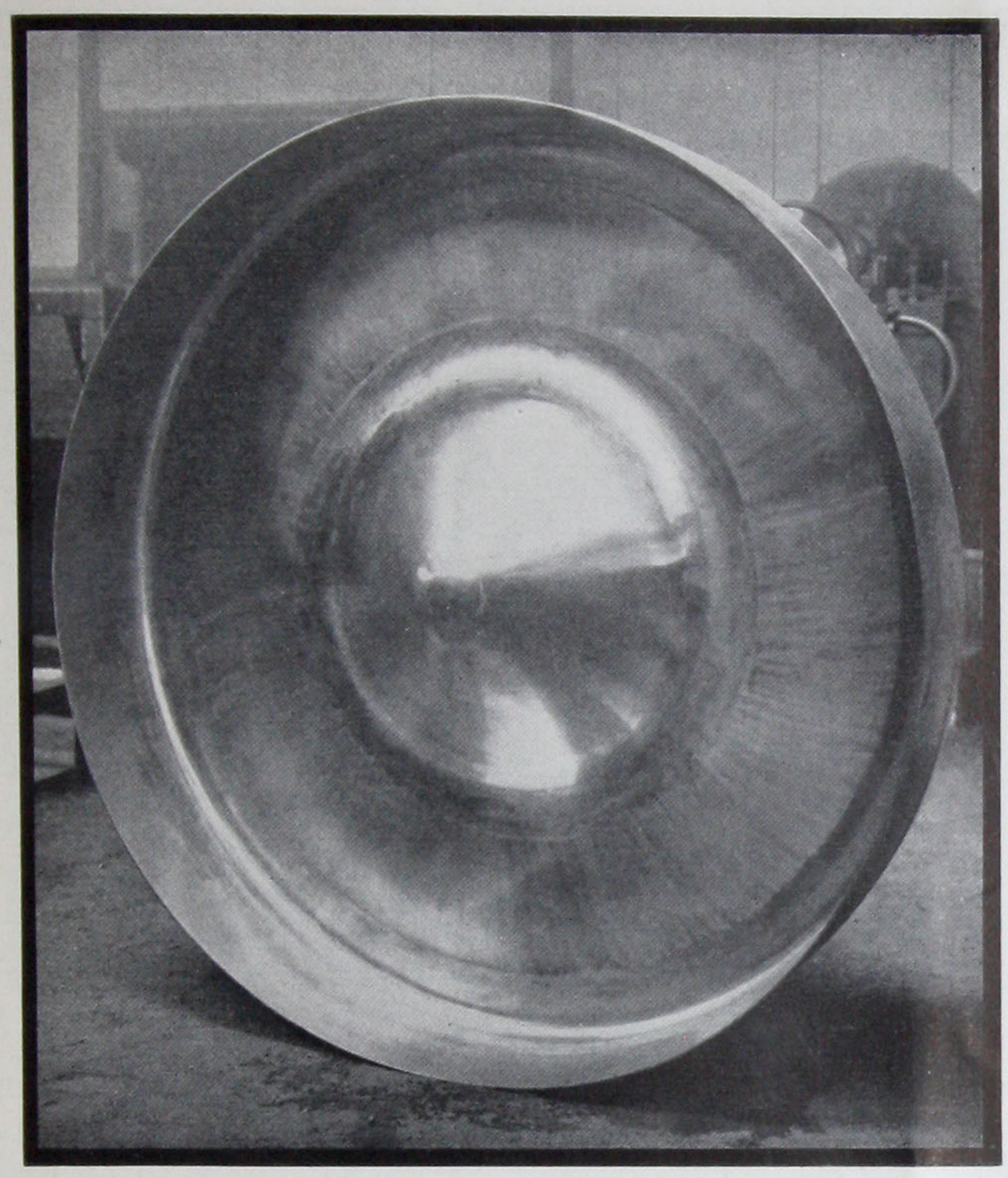
The boundary lines between these three groups of steels are not clearly defined, so that the above classification is only approximate both as to the chromium content and the physical and chemical properties.

There are three fairly well defined classes of the stainless steels in the second group. The first contains from 12 to 19 per cent chromium and not over 0.10 per cent carbon, and its rustless or stainless properties do not require development by heat treatment. The second class contains from 12 to 15 per cent chromium, with a carbon content of 0.25 to 0.40 per cent. It hardens upon quenching, and is not suitable for deep drawing or forming. Careful heat treatment and polishing are required in order to develop most completely its corrosion-resisting properties. The third class comprises the austenitic chromium-nickel alloys which contain about 17 to 20 per cent chromium and 8 to 10 per cent nickel.

The chromium-nickel alloy steels, of which the well-known "18-8" is typical, have become increasingly popular in this country, until at the present time applications for this metal have been found in practically every industry. Stainless steels are particularly well adapted for use in resisting atmospheric corrosion, attack from oxidizing agents, and scaling at elevated temperatures. With their high physical properties and broad range corrosion resistance, progressive designers are continually finding new uses for stainless steels in place of ordinary steel and cast iron.

It is interesting to note how the consumption of stainless steels in various fields grows as the merits of these alloys are appreciated and applied. A survey of the major consumers showed the petroleum industry to be in the lead in 1930. The automotive, chemical, architectural, food preparation and distribution, paper, laundry, aviation and marine fields followed in the order given.

This kitchen is completely equipped throughout with 18-8 chrome-nickel steel, thus insuring beauty and cleanliness at all times



Milk bottle filling machine head made entirely of 18-8 chrome-nickel steel

The ready adaptability of the stainless chromium-nickel steels to the food and associated industries brought about such a rapid advancement that this field climbed to the head of the list of users in 1931, while the petroleum, automotive and chemical industries kept the same position in relation to each other. High temperature and pressure work climbed up to fifth place, followed by ship-building and architectural trim for buildings. Completing the list of major consumers were the aircraft, railroad, paper and hospital fields.

A survey of the particular uses of stainless steels in these major fields is extremely interesting because of the diversity of applications shown.

Food Industry

Under this heading are included the equipment and containers used in the preparation, packing and distribution of foods, and the household culinary appliances which have recently become so popular.

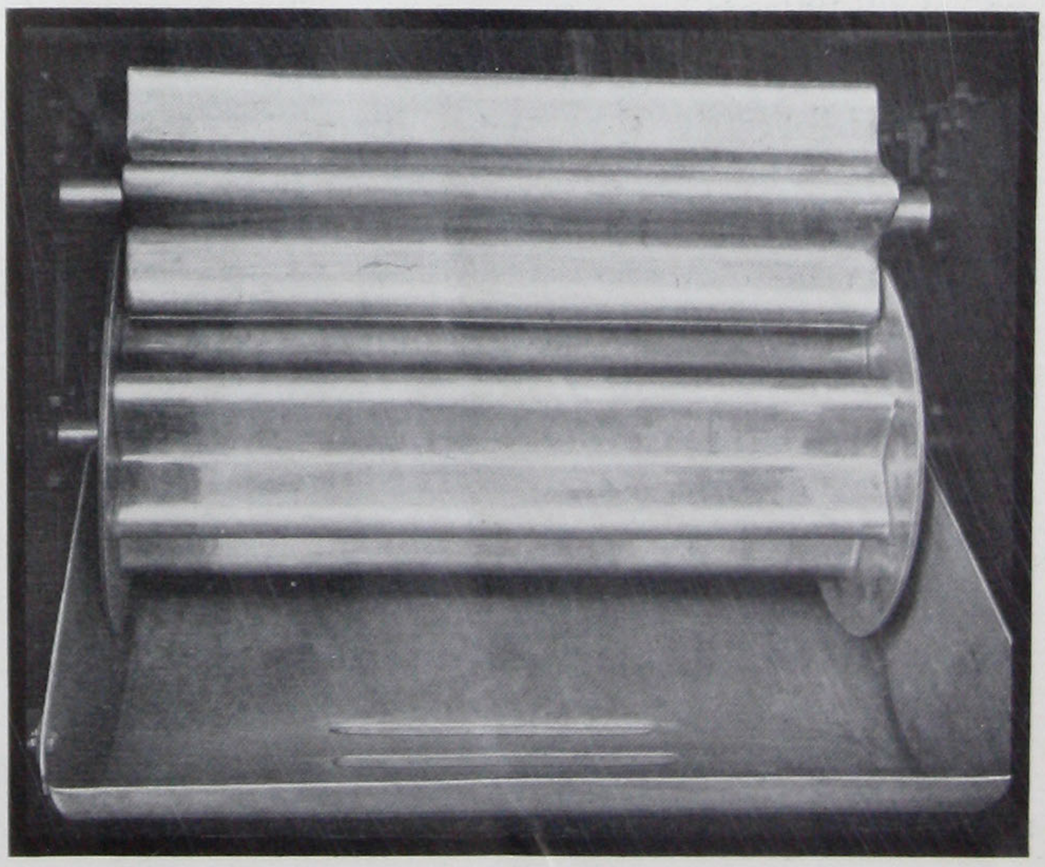
Probably the largest application in this field is the use of stainless steel containers. Ranging in size from small cans to tanks for trucks and freight cars, these containers are rapidly becoming increasingly valuable in the shipping of milk, fruit juices, beverages, and all foods which have a tendency to corrode the materials formerly used, or which are affected by contact with ordinary metals.

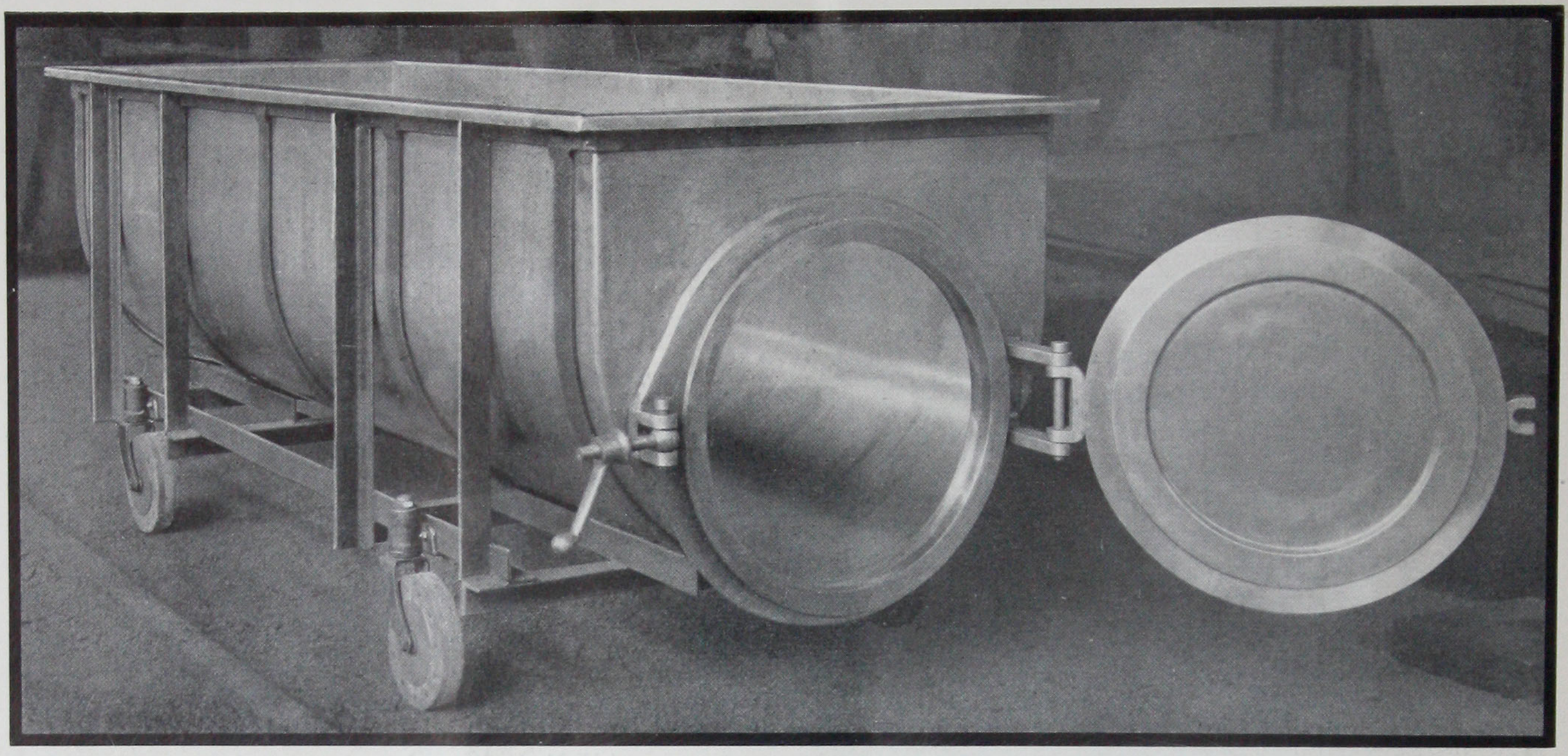
Equipment used in preparing various foods has shown greatly improved performance when stainless steel has been used for parts subject to rusting or corrosion. Beaters, mixers, paddles, vats and drums found in bakeries, candy factories, bottling works, are being fabricated to a large extent from 18-8 chrome-nickel steel.

A partial list of the stainless steel equipment used in the dairy branch of the food industry follows:

Circulating type horizontal vat pasteurizers:
  All linings and jackets
Spray pasteurizers:
  All linings and jackets
Continuous pasteurizers:
  All linings and jackets
Paddle-type pasteurizers:
  Linings, jackets and paddles
Tank compartments for milk trucks

These corrugated rolls of 18-8 chrome-nickel steel are part of an orange-crushing machine





All-welded stainless steel soak cars and tanks used for conveying fruit pulp in making beverages

Tank compartments for freight cars
Automatic milk holders:
  Compartments and jackets
Cylindrical storage tank linings
Air actuated holders
Homogenizers:
  Pistons, cylinders, suction valve seats, discharge valve seats, valve rods
Condensers
Vacuum pans
Steam chests for condensing vacuum pans
Sterilizers
Revolving vertical coil vats
Surface coolers:
  Tubing, headers, and fins
Internal ammonia coolers
Weighing tanks and cans
Dump tanks
Bottle fillers:
  All sheet metal and tubes in contact with milk
Pipe line filters
Ice boxes
Valves and fittings of all kinds
Ice cream cabinets, linings and covers
Tables
Butter boxes for butter printers
Recording thermometers:
  All metal parts coming in contact with the milk

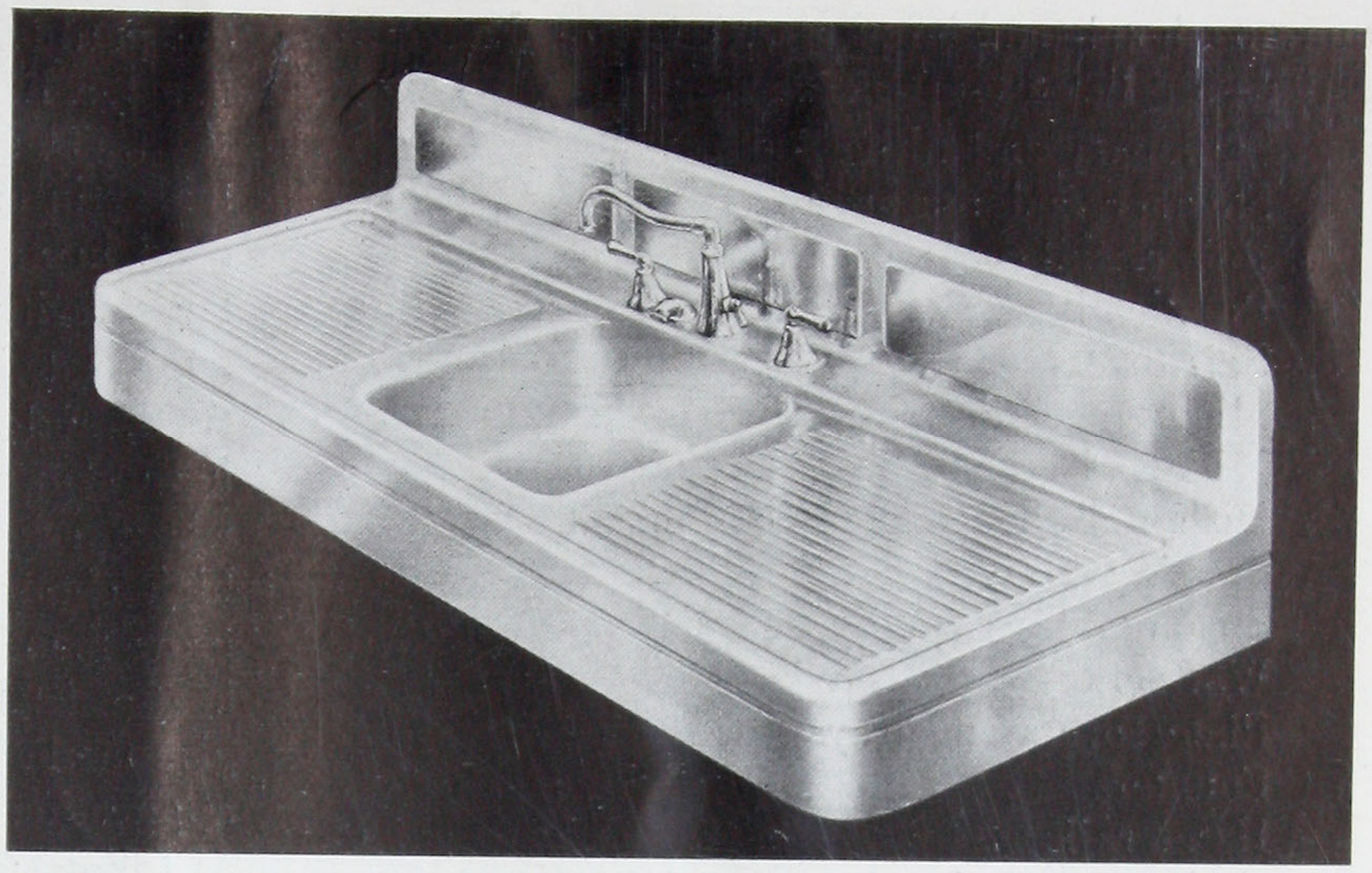
This list might be considered typical of the uses to be found in other branches of the food industry. Wherever fruit juices, fatty acids, or foods come in contact with metal, stainless steel will be found to be particularly advantageous.

In the fruit handling field stainless steels have been widely used for fruit knives, corrugated rolls for crushing machines, canning equipment such as dippers, pails, vats, pipe lines, cookers and conveyors.

Bakeries use chrome-nickel steel for dough mixers, troughs, baking pans, spoons and dippers.

A considerable amount of this material is used in equipment of packing houses where metal parts come in contact with animal fats and acids and consequently are subject to corrosion.

Probably one of the most popular uses of stainless steel is in kitchens, particularly those of res-



Stainless sinks of 18-8 chrome-nickel steel add beauty and cleanliness to any pantry or kitchen

Stainless steel tableware retains its spotless beauty permanently

Stainless steel kitchen utensils will not rust or tarnish and are not affected by food acids

taurants, hotels and hospitals. A few of the applications are listed below:

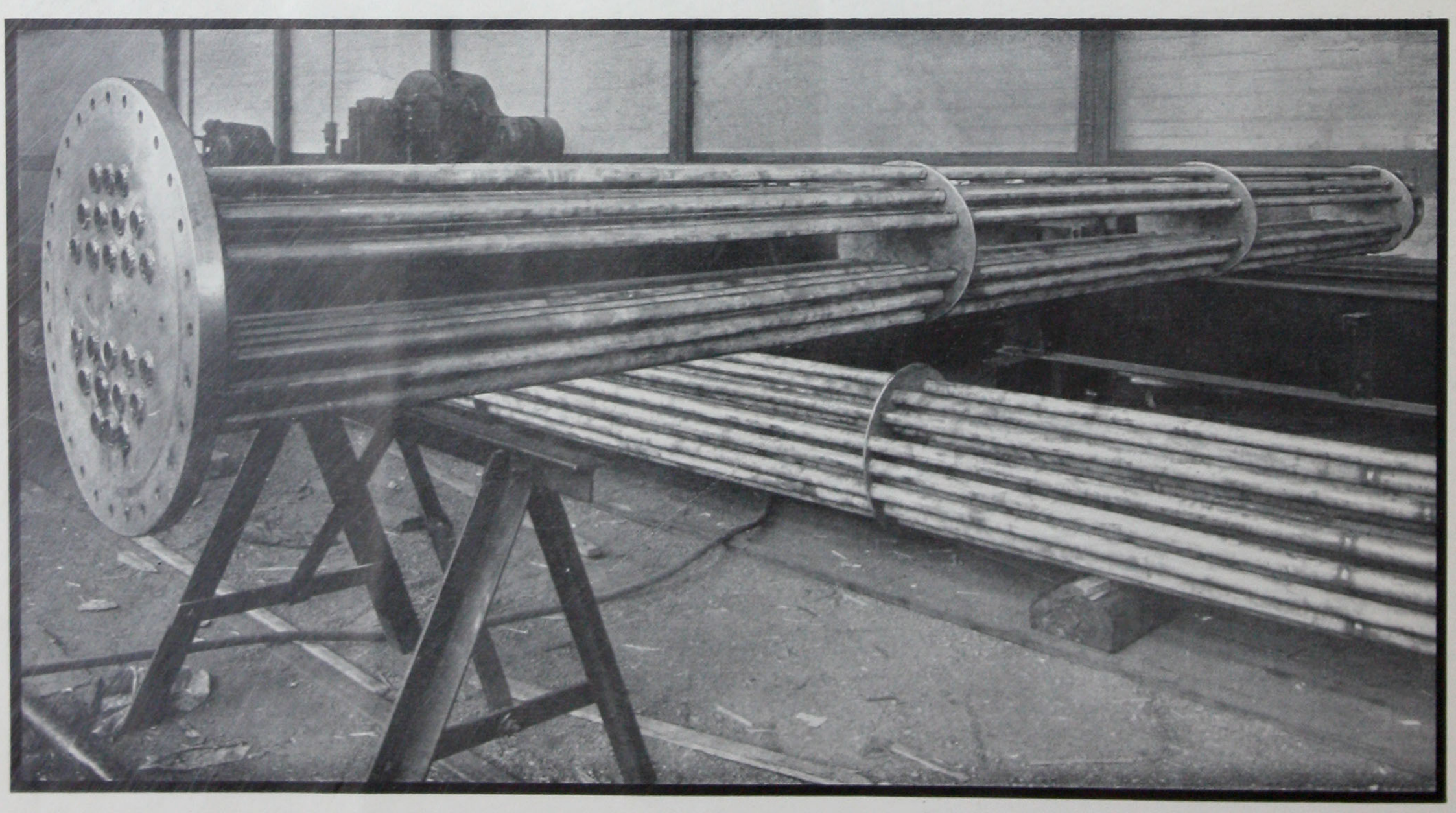
Stationary and tilting kettles
Steamer and roaster parts
Boilers and cookers
Practically every kind of cooking utensil
Salt driers
Slicing machines
Milk and cream dispensers
Dish and glass washing equipment
Cook's tables
Steam tables
Warmers
Plate covers and trays
Counters
Hand rails
Cutlery
Refrigerator and stove trim
Covers for commercial mayonnaise mixers
Ice containers for shipping fish

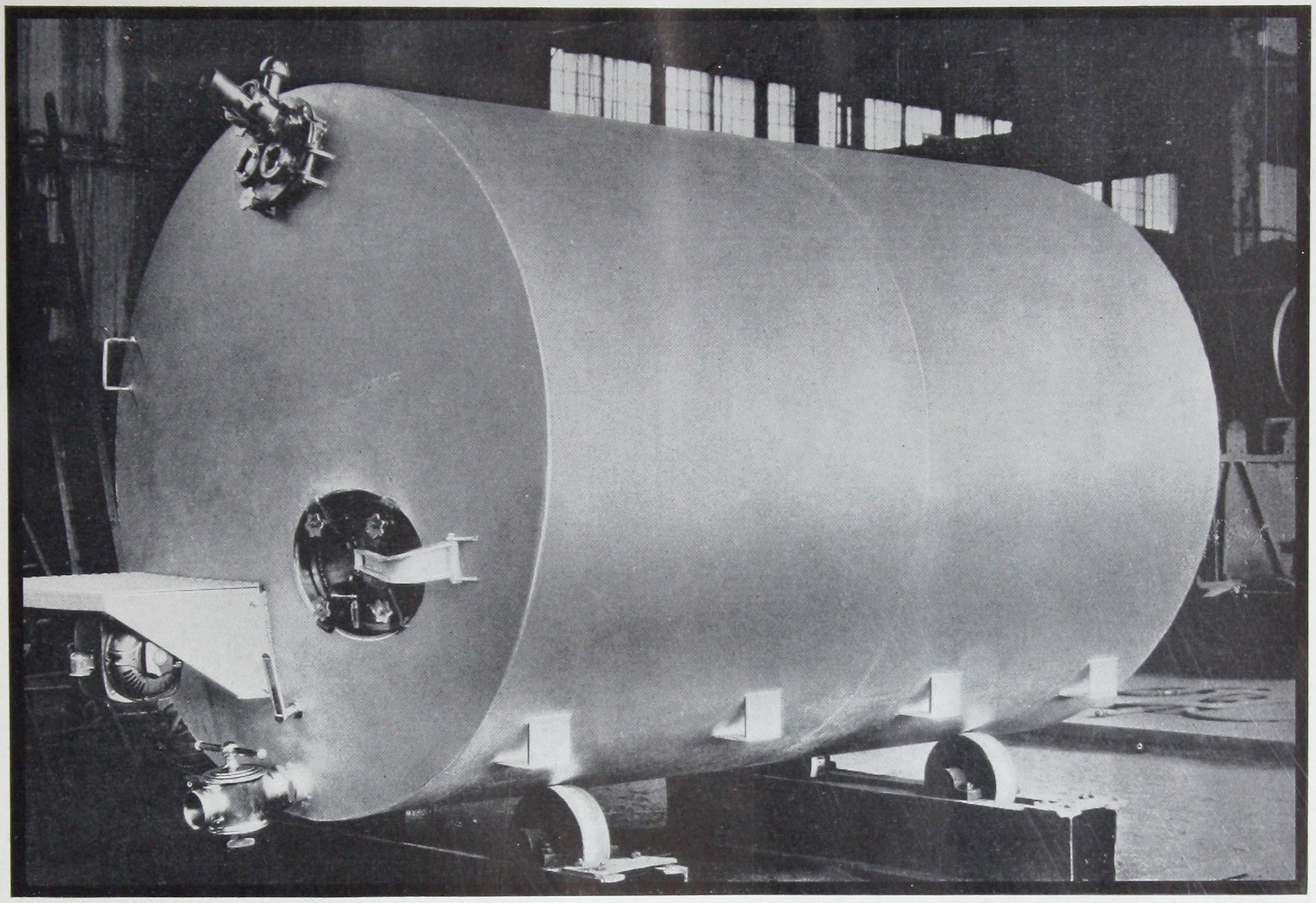
Petroleum Industry

The extremely corrosive agents encountered in the petroleum industry attack metals so rapidly that the life of ordinary steels is frequently very short. The length of service of plain carbon steel tubing in cracking and refining operation is reckoned in months, and frequently in hours, so that the severity of the action on metal can be readily appreciated. Various types of alloy steel have been tried, and at the present time the stainless steels have shown the best results. In some instances where crude oil has a high sulphur content, a high chromium steel that is low in nickel may prove the most suitable. Where great strength and heat resistance are desired, the chrome-nickel steels give the best results. Some of the more important applications of the stainless steels in this field are as follows:

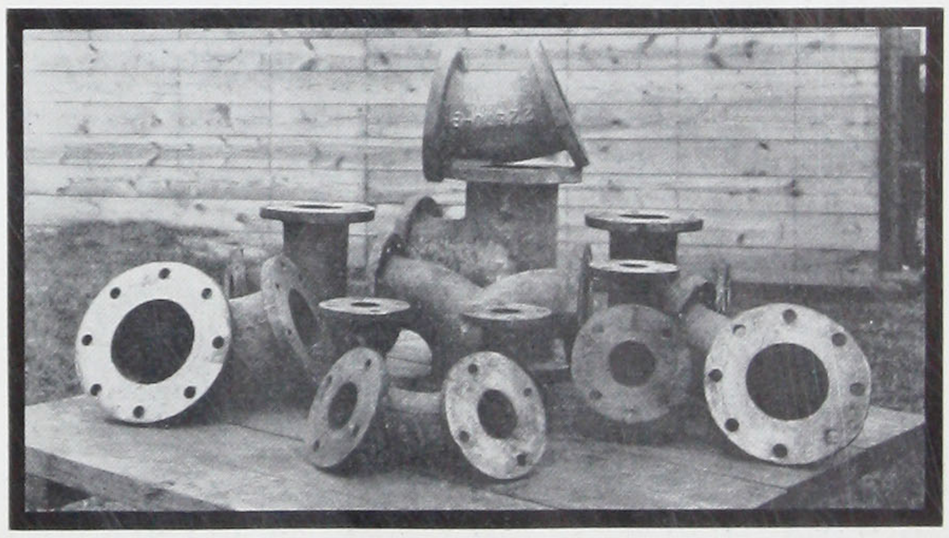
Oil still tubes, valves and fittings
Tube supports, hangers and sheets
Header boxes and return bends
Bubble caps and plates
Swing lines in sour crude oil storage tanks

These tubes of stainless steel are used to combat the intense corrosion encountered in the petroleum industry

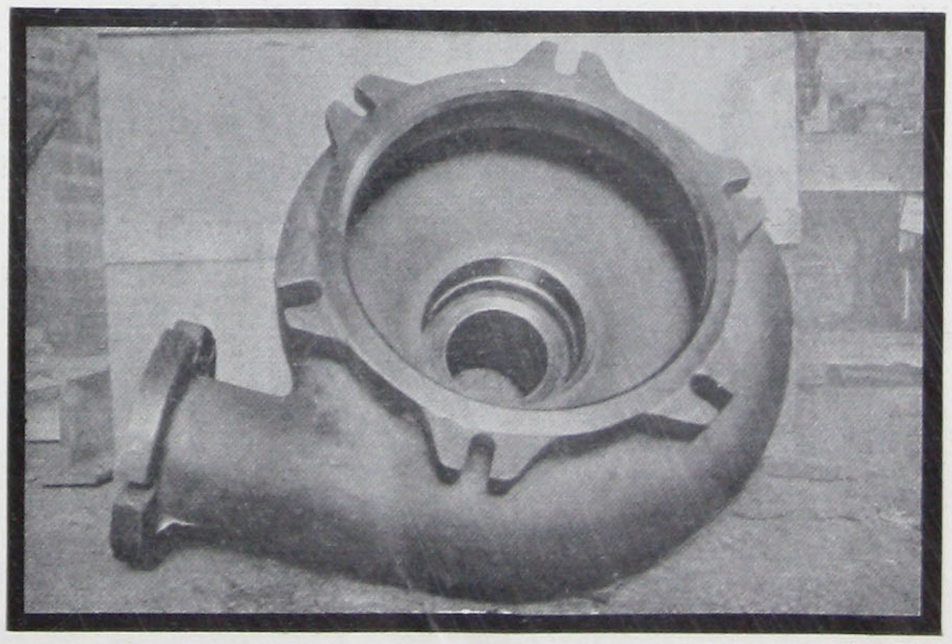




The stainless steel lining of this 3000 gal. milk storage tank insures clean, sanitary working conditions



These castings containing high percentages of chromium give extremely long life under severe operating conditions



This casing for a sand pump for acid mine water must resist wear and acid corrosion. It contains 27 to 30 per cent chromium

Steel-jacketed steam kettle lined with stainless steel for handling hot acid. Note welded joints

Bubble cap trays
Pump parts, pipe fittings and stop cocks
Hot oil pumps:
Valves, nuts and bolts, wet-end pistons
Ball valves and valve seats
Air preheaters

Door hinges and handles
Cowl lamps, beading and stop lights
Dashboard trim
Curtain glass frames
Gasoline tank caps and radiator caps
Pump shafts

Automotive Industry

The major use of stainless steels in the automotive industry is for trim which will not rust nor tarnish. They are also used to a large extent for certain parts, such as pump shafts, which are subject to corrosion. Stainless steel meets these requirements perfectly since it is easy to keep clean and bright. In addition, its deep drawing and forming properties make it a suitable material from the point of view of the manufacturer. Some of the uses of stainless steel for automobiles are given below:

Radiator shells
Head lamps
Bumpers
Fenders
Hub caps and wheel spokes

Chemical Industry

The greatest need in the chemical industry is for a corrosion-resistant metal suitable for use in equipment coming into contact with highly active chemicals. As yet, no one alloy has been developed which will meet all requirements, but stainless steels have gone far in meeting the situation. An extensive field for these steels has been opened up by their great resistance to attack from nitric acid and other powerful oxidizing agents. There are innumerable pieces of apparatus and equipment parts fabricated from stainless steels; but the accompanying list may be considered typical:

Nitric acid equipment:
Pipe lines, vats, valves, towers, drums and tank cars
Pails and nozzles for handling sulphuric acid

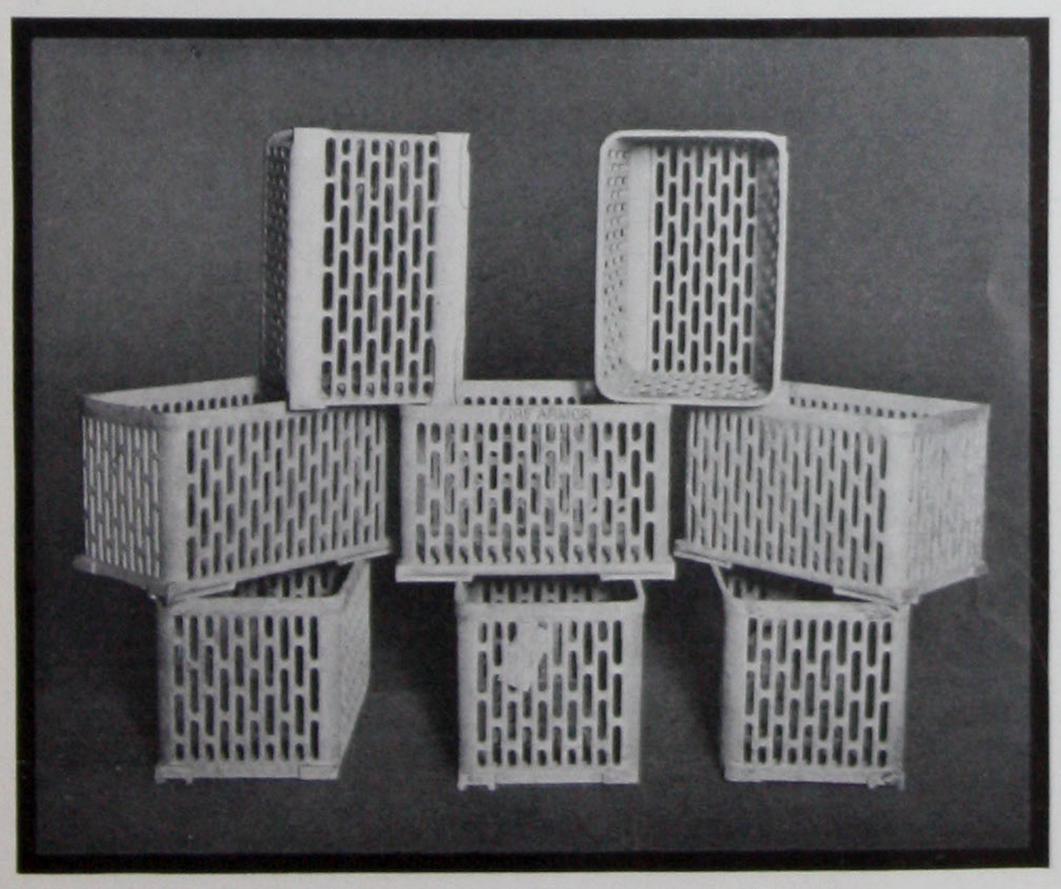
Pickling tanks
Acid tanks of many types
Retorts
Condensers
Stills
Digestors
Evaporators
Heat exchangers
Autoclaves
Coils, piping, valves, seats and fittings
Mill liner-plates
Pump rods, plungers, shafts, casings, etc.
Conveyor shafts
Agitator blades
Filter screen

High Temperature and Pressure

Stainless steels are notably resistant to high temperature oxidation. Experiments have shown that a thin adherent film containing chromium oxide is formed on the surface of the metal which retards further oxidation to a marked degree. This desirable property of stainless steel opens up a vast field for its use as heat-resisting parts.

Long time tests have indicated high creep-strengths at elevated temperatures. This is a most important feature of any metal subjected to high stresses at elevated temperatures, and it has resulted in an increasing use of these steels for equipment operating under highly adverse conditions. The following applications have found favor in the high temperature and pressure fields:

The chromium content of these annealing boxes combats oxidation at high temperatures



Furnace flue valves
Furnace door arches
Vapor condensers
Return bends
Furnace plates, spiders and retorts
Checkerwork supports for blast furnace stoves
Oil burner nozzles, fire-pots, and combustion bowls
Retorts
Annealing boxes
Calcining retorts
Lead and cyanide dipping baskets
Enameling bucks, racks and hangers
Glass rolls
Normalizing furnace rolls
Conveyor links
Skid rails for billet heating furnaces
Smelter bins
Blower fans
High temperature and pressure bombs
Instantaneous water heater coils
Piping, valves and fittings of all types
Rabble arms for roasting furnaces

Marine

The potential field of application in the marine industry is enormous and progress is being made in introducing stainless steels for fittings and parts subjected to the action of sea water. Great resistance to salt air, spray and immersion in sea water renders them particularly well adapted to the brightwork and rigging about a ship, one of the largest uses of stainless steel wire rope being for yacht rigging. Their durability justifies their use for parts more or less continuously immersed in salt water, a notable instance being in cables and superstructure used on submarines. The following may be considered representative uses in this field:

Passenger and cargo ships:
- Deck fixtures
- Galley trim
- Pantry, dresser and table tops
- Barber shop trim
- Cabin fittings
- Marine hardware
- Door panels
- Fireplaces
- Hand rails
- Rigging
- Landing floats

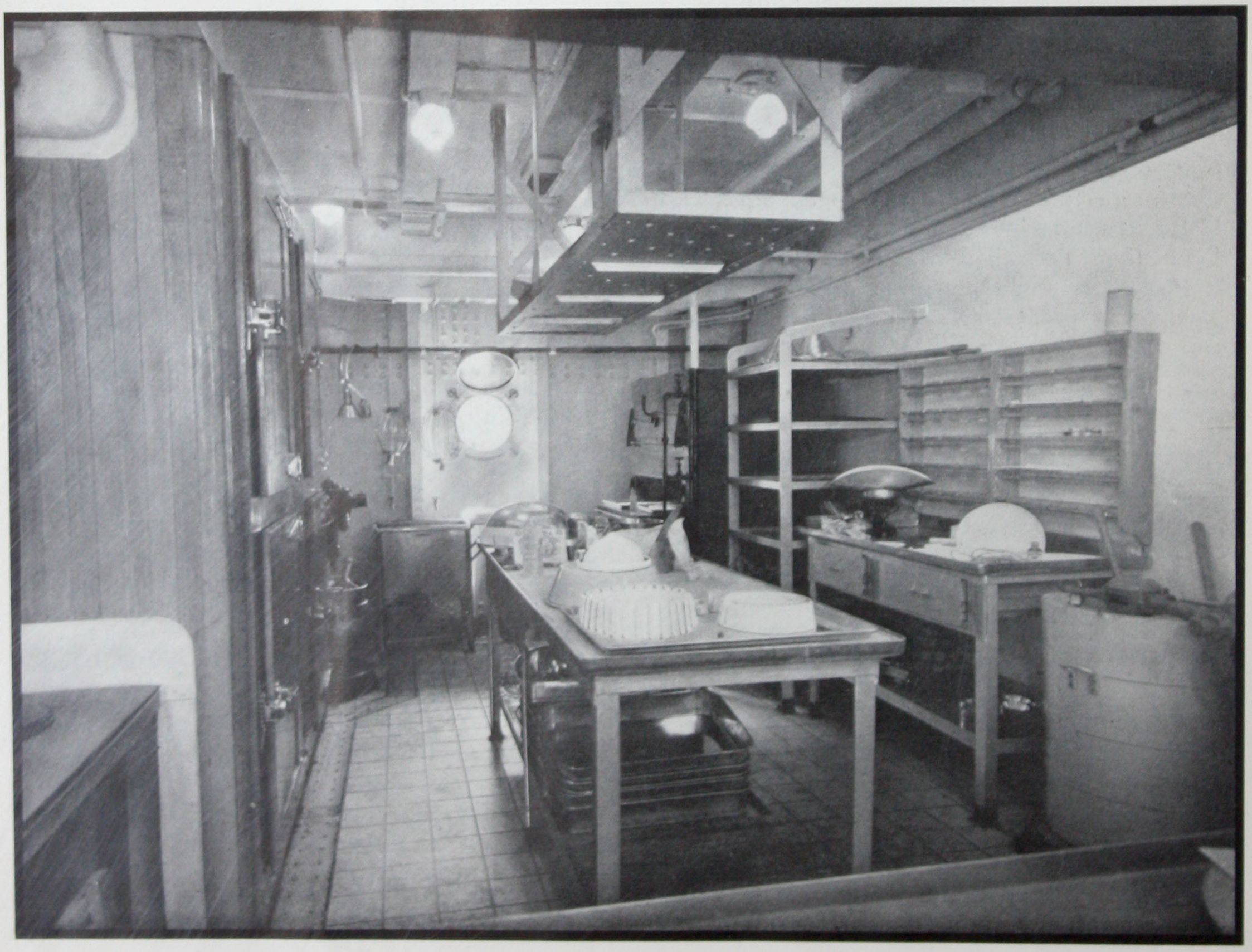
Motor boats and small craft:
- Outboard motor parts
- Fender strips and wales
- Cut-waters
- Chocks, cleats, etc.
- Windshield brackets

Gasoline and oil tanks
Propellors
Shafts
Pump parts

Architectural Uses

As in the marine and shipbuilding fields, stainless steels are used by architects and builders for increased utility and lasting beauty. The corrosion-

Stainless steel was used for work tables and dressers in the culinary department of the S. S. Manhattan



The stays, halyards and fittings of the ketch Ayesha are made of 18-8 chrome-nickel steel

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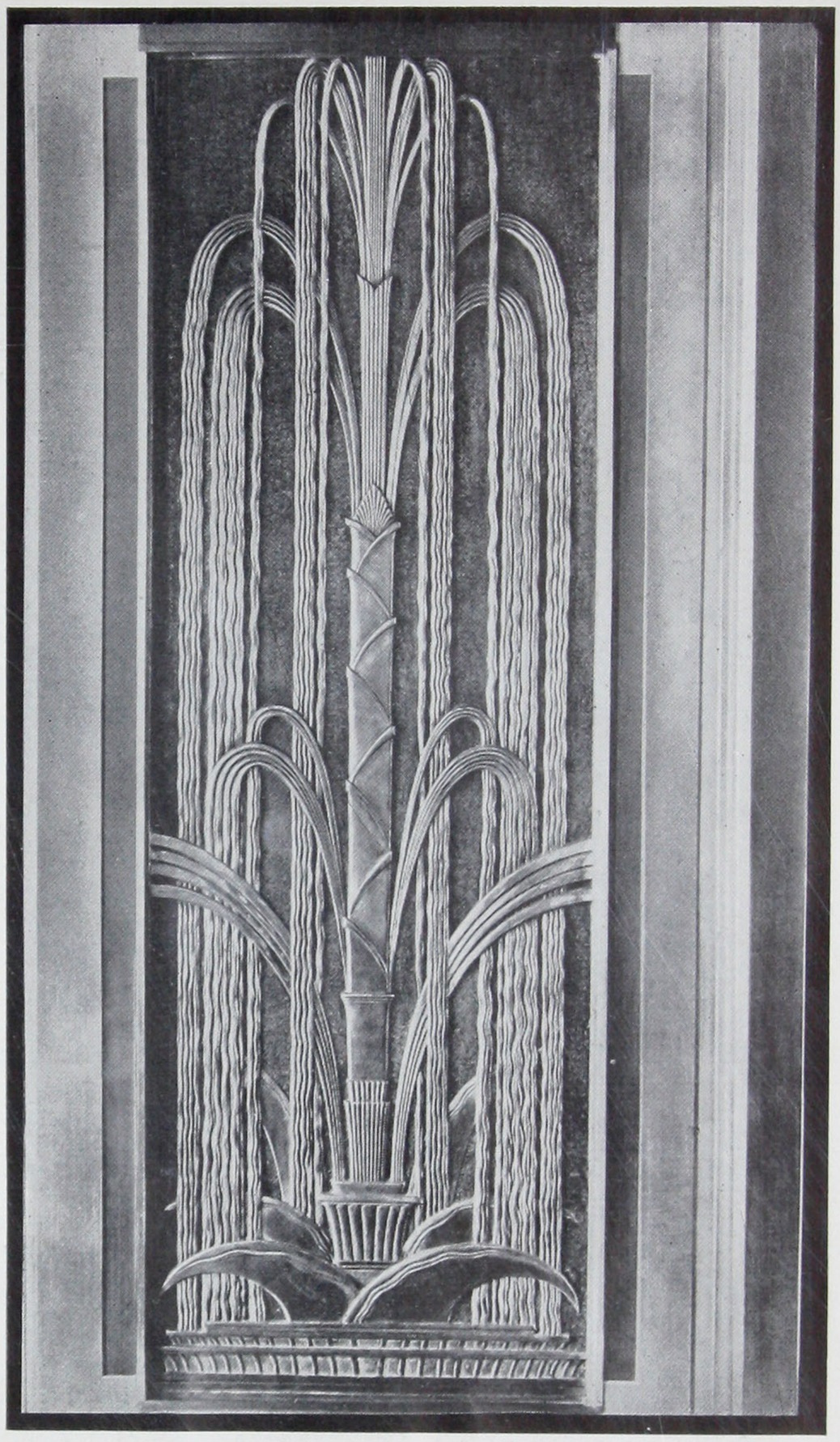

This door panel is typical of the pleasing effects possible with cast stainless steel

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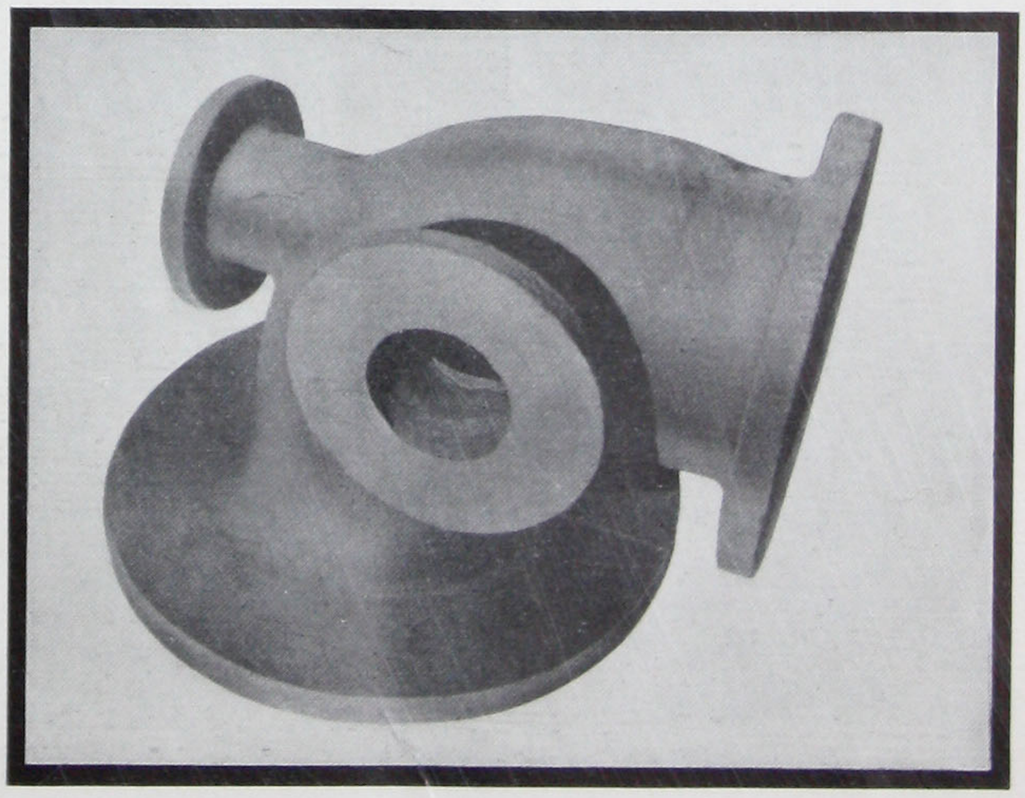


This 24-12 chrome-nickel fitting has been in service in a sulphite paper mill for three years

resistant properties of these steels make them invaluable for use where a permanent, gleaming, silvery finish is desired. In the larger cities the air is frequently polluted with smoke, dirt and gases which wreak havoc with the exterior trim of buildings. The permanence and beauty of stainless steels has led to their extensive use as trim of such well-known edifices as the Empire State Building and the Chrysler Tower in New York, and the LaSalle-Wacker Building in Chicago.

The popular demand for household appliances that can readily be kept spic and span has resulted in a demand for stainless steel furnishings in homes and public buildings. The accompanying list is typical of the applications found in the structural and decorative fields:

Exterior building trim:
- Window sash, spandrels, mullions, towers, balconies, grilles, screens, etc.

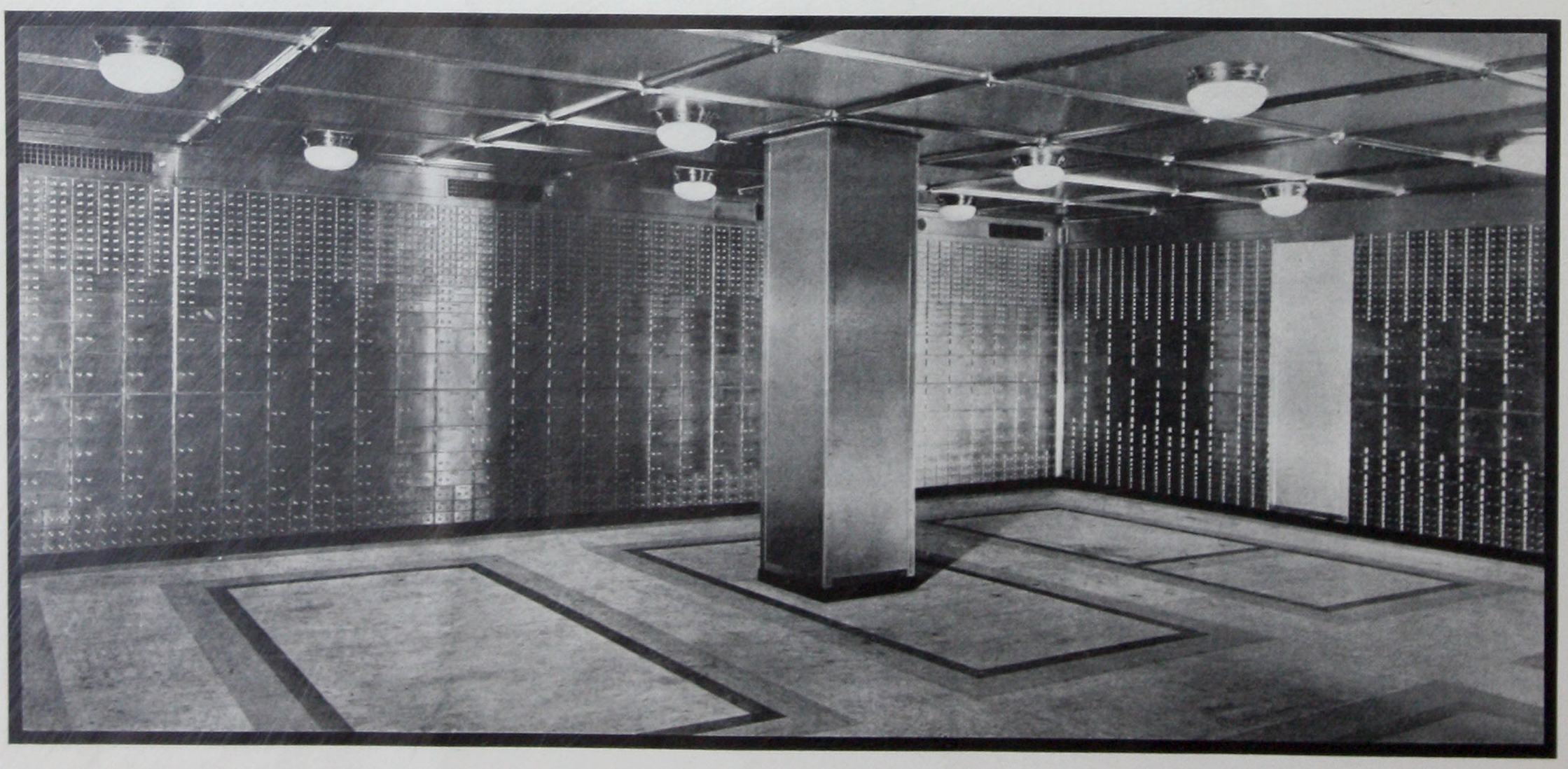
Interior trim:
- Elevator lobbies, vestibules, hand rails
- Overmantles, ceilings and window curtains
- Bank cages and fixtures
- Vault linings and safe deposit boxes and doors
- Mirror frames, nameplates, etc.

Household equipment:
- Boilers
- Cooking utensils
- Cutlery
- Table tops, sinks and refrigerators
- Wainscoating
- Plumbing fixtures
- Trim for kitchen ranges
- Tables and chairs
- Lamps and clocks
- Fireplaces and fire screens
- Hardware of all types

Structural:
- Wire rope
- U-bolts for underwater construction
- Covered bridges

Hydraulic construction

The safe deposit boxes, columns and trim of this modern bank are beautified with sheets of straight chromium steel



This pneumatic tired rail car fabricated entirely of stainless steel is remarkably light for its size and is an innovation in car construction

Railway Field

The use of stainless steels on the railroads is in the early stages of development, but there are several applications now undergoing test which promise to have far reaching effects on railway operation. The profitable operation of railway branch lines lies in providing fast, frequent and low cost service. Modern rail cars of conventional design weigh from 130,000 to 240,000 pounds, and if self propelled, require motors of 300 to 900 horsepower.

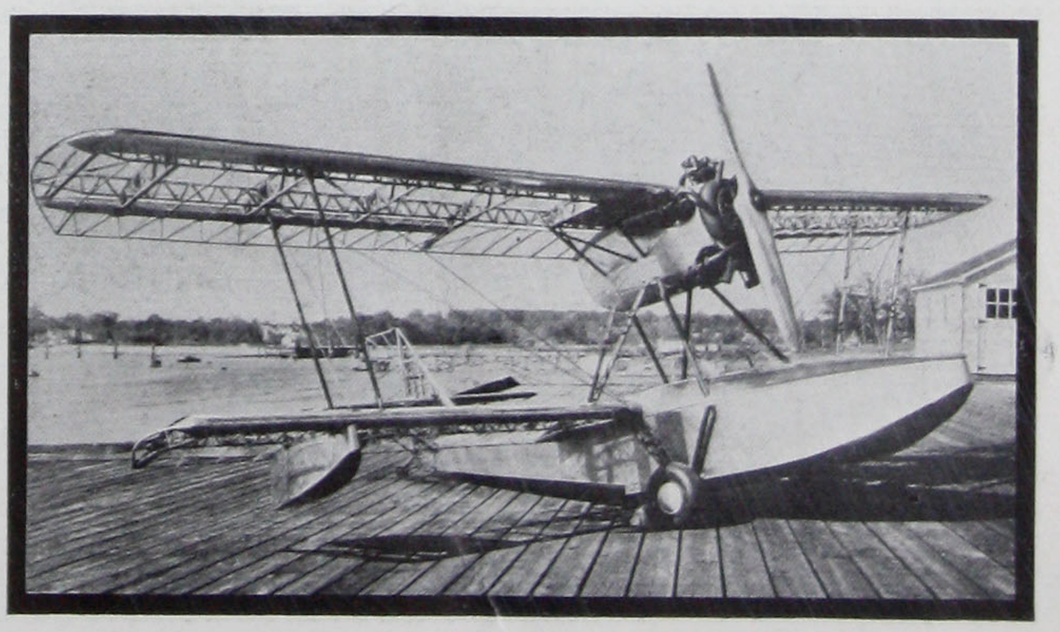
A railway passenger car was recently built entirely of stainless steel. This car, which seats 47 passengers, weighs 22,000 pounds, and requires 90 to 125 horsepower for its operation. The remarkable saving in dead weight and consequent reduction of motive power was made possible by the high strength of this steel and the fact that extremely thin sections could be used without fear that corrosion might eventually impair the strength of these sections. In designing this car safety was the first consideration and the factor of safety is equal to that of an ordinary car weighing ten or more times as much.

The high creep strength and resistance to oxidation of stainless steels at elevated temperatures renders them suitable for use in locomotive firebox side sheets, condenser tubes, arch supports, and superheater parts. In addition to the tank cars already mentioned under the dairy and chemical industries, stainless steels are well adapted for trim and utensils in dining cars, and plumbing fixtures on Pullman cars and passenger coaches.

Aircraft Industry

At first the use of stainless steels in aircraft construction was considered feasible for only a few special parts. However, a plane was recently built in which all structural members were of 18-8 chrome-nickel steel. An interesting and novel feature in the design of this plane is the construction

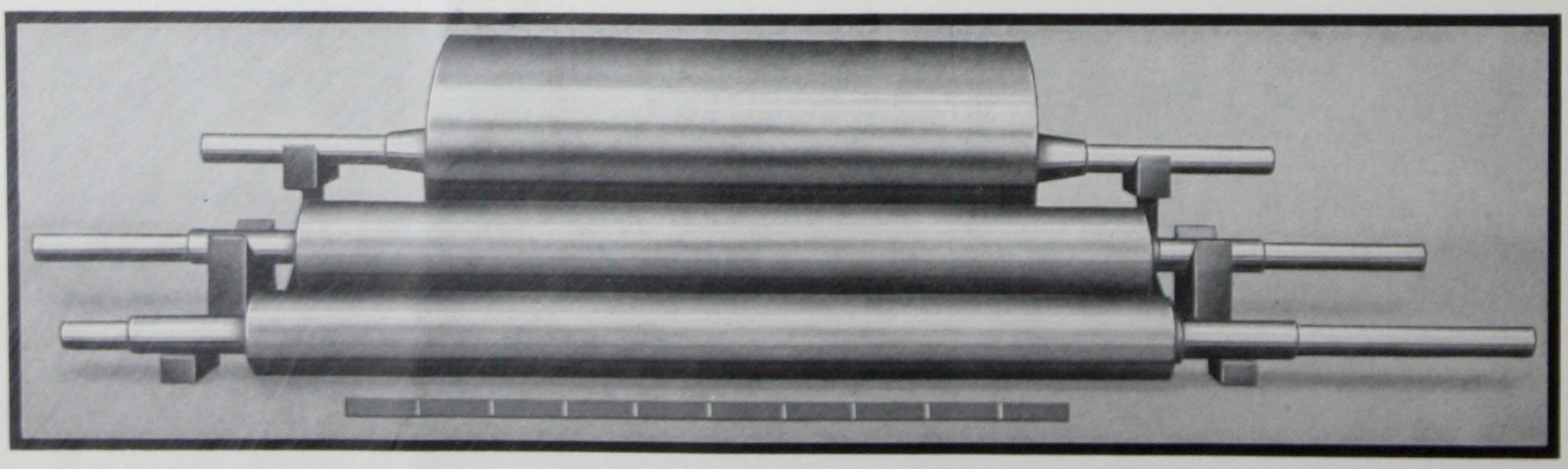
Seaplanes like ships, are corroded by salt sprays. The use of 18-8 chrome-nickel steel for structural parts of this plane overcomes this problem



The use of 18-8 chrome-nickel steel float gear on this seaplane insures resistance to corrosion from sea water

of the wings and rudder. They were built up of welded channels and angles over which stainless steel gauze was stretched and then coated with a filler of transparent resin. With this construction it was possible to obtain from 12 to 20 per cent greater strength in the members without any increase in weight. The assurance of freedom from corrosion is probably the most important factor in the fabrication of metal parts. Stainless steels are frequently used for cabin fittings, wing beams, cockpit control parts, exhaust manifolds, control cables, and pontoons for seaplanes.

Stainless steel helps to solve many problems in the dyeing industry. These rolls are of 18-8 chrome-nickel steel



Dyeing Industry

Stainless steel may be used to advantage for equipment in the dyeing industry because it offers all the advantages of materials formerly used without any of their disadvantages. Wooden vats which have been largely used in the past in dyeing operations have two distinct disadvantages: (1) prolonged boiling out operations are necessary when it is desired to change from one color to another, and (2) splinters frequently develop which cause damage when delicate fabrics are being treated. For these reasons wooden vats may in many cases be replaced to advantage by stainless steel vats.

Experience has shown that stainless steel is an ideal material for this application. When changing dyeing solutions from one shade to another it is only necessary to drain out the vats and rinse them with a stream of water from a hose. The time required to change from one color to another is so much less when stainless steel vats are used that in some cases one vat has replaced ten or even fifteen wood vats. Stainless steel is being used to advantage for the following dye house equipment:

Vats
Pumps, valves and piping
Reels and rolls
Agitators
Spray pipes
Buckets and dippers
Dye sticks
Yarn tubes and racks

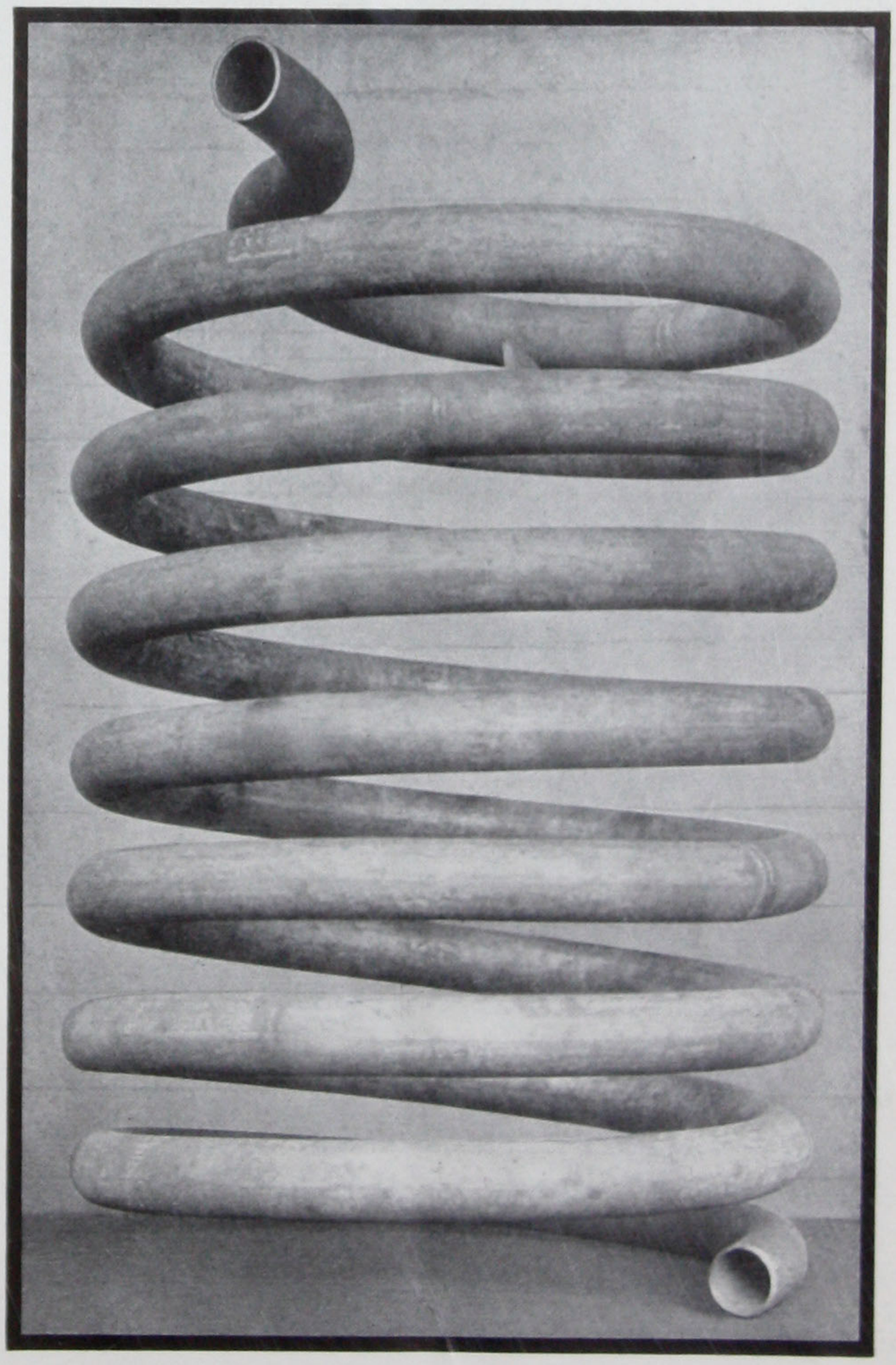
Brewing Industry

Many materials have been used for the construction of vessels used in the brewing industry, but many of them possess some very definite disadvantages. Some are difficult to fabricate, others are hard to keep clean, while others cause a "haziness" or turbidity in the beer. Some of the metals impart an undesirable flavor to the beer; some are easily attacked by the chemical cleansing agents used; while others adversely affect the fermentation process.

Stainless steel has been shown, both by laboratory tests and by actual use in breweries, to be an ideal material for brewing equipment. It does not affect the flavor, color, brilliancy, fullness of the beer, nor does the beer attack stainless steel. The following list includes various applications of stainless steel in the brewing industry:

Yeast pans
Fermentation vats
Storage and auxiliary tanks
Cooling coils
Syphons
Measuring vessels
Clarifier slats
Filters
Heat exchangers
Bottling machinery

Coils of stainless steel are fabricated into many sizes for numerous industries. This coil of 4 in. I.P.S. is used in soap manufacture



Beer barrels of 18-8 chrome-nickel steel are being used in increasing volume because of their inherent advantages over other types of casks

Miscellaneous Applications

Practically every industry has some equipment in which the use of stainless steels would prove of value. To completely cover these applications in detail would be impossible. The following list consists of typical examples taken from the fields not already covered:

Hospitals:
- Pans for x-ray tables
- Sun lamp reflectors
- Oxygen room and tent fixtures and parts
- Baby incubators
- Humidifiers
- Operating room equipment
- Kitchen equipment
- Instruments

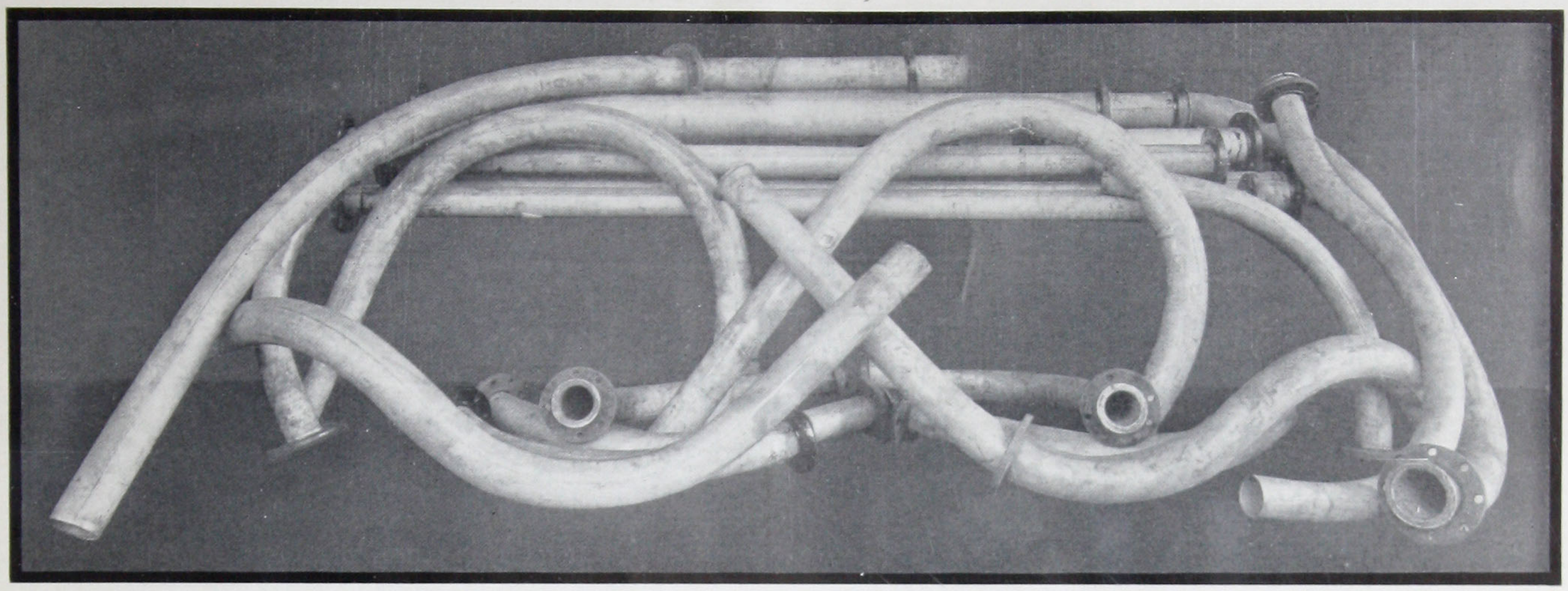
Paper mills:
- Blow pit bottoms
- Relief gas lines and coolers
- Acid circulation systems
- Digestor linings

Corrosion resisting wire and wire rope
Steam turbine blades
Motion picture film developers
Blueprint machines
Tanks for zinc plate etchings
Clamps for phone directory stands
Manhole steps for sewers
Street lane and traffic markers
Caps for surveyor's bench marks
Screws, bolts, and nuts of all kinds
Laundry equipment
Barber shop and beauty parlor appliances
Soap manufacturing equipment
Dentures
Dental instruments

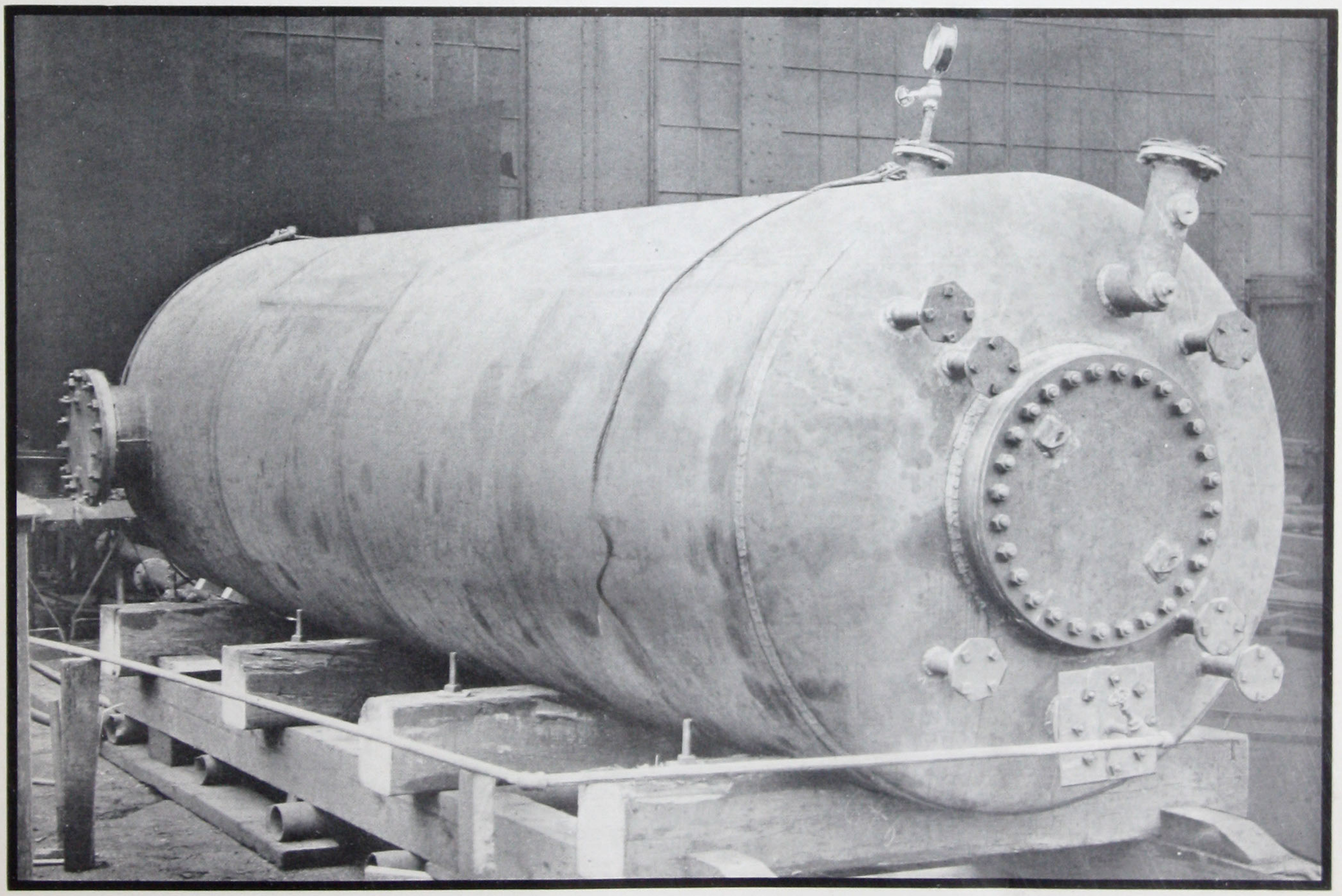
Jewelry:
- Watches, settings, vanities, cigarette cases, etc.

Laboratory apparatus
Trunk corners and trim
Golf clubs

The examples herein mentioned are but a few of the many ways in which stainless steel may be used beneficially. Since the manufacture and fabrication of stainless steels have been placed on a commercial basis, new applications are being constantly found, and the development and expansion of their use have been truly remarkable.



These 4-, 5-, 6-, and 10-in. diameter welded stainless steel pipes are used for handling hot sulphite liquor in paper manufacture



Large pressure vessel of 18-8 chrome-nickel steel 7/16 in. thick, with flanged and dished heads used for soap manufacture

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